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SOLAR PHYSICS OBSERVATORY

THIRD ANNUAL REPORT OF THE DIRECTOR OF THE SOLAR PHYSICS OBSERVATORY TO THE SOLAR PHYSICS COMMITTEE

1915 APRIL 1—1916 MARCH 31

Third Annual Report of the Director of the Solar Physics Observatory

1 *June* 1916.

The Vice-Chancellor begs leave to publish to the Senate the following Report which the Solar Physics Committee have received from the Director of the Solar Physics Observatory :—

The Report here presented relates to the year 1915 April 1 to 1916 March 31. The work of the Observatory has been carried on under conditions increasingly disadvantageous on account of the war.

The Assistant Director, Mr Stratton, has been absent the whole year; as Captain in the Royal Engineers (20th Signal Company) he has been with the British Expeditionary Force in France since July last, and was mentioned in Sir John French's despatches in January. He was gazetted Major on April 8, 1916. The First Junior Observer, Mr Rolston, received his commission and left the Observatory in June last to join the 2/5th Weald of Kent Battalion (The Buffs). He was gazetted Captain on April 12, 1916. The Second Junior Observer, Mr Moss, has been training with the Officers Training Corps during most of the year, but has been able to devote half time to duty at the Observatory until March 29, 1916 when he left to take up duties in the Inspectional Department at Woolwich Arsenal. The Resident Attendant, W. H. Manning, has since May last been engaged in munition work in Cambridge.

The continued detention at Odessa of the apparatus taken to the Crimea in July 1914 for the solar eclipse has put obstacles in the way of work in many branches.

A. *Stellar Work.*

Observational work with the Newall Telescope and the Huggins instruments has been in abeyance throughout the year.

The Director's plans for the staging required for manipulating the 3-foot Reflector were put in the hands of Messrs Cooke and Sons, who completed the working drawings of the design but have not been able to put the construction in hand.

The work on the preparation for an atlas of typical stellar spectra has been interrupted by the diversion of the assistant from the required photographic work to munition work. But, in the assignment of chemical origins of lines in stellar spectra, much progress has been made by Mr Baxandall, who for this purpose has completed a preliminary revision of the origins given to solar lines in Rowland's Tables of Solar Spectrum Wavelengths.

By reference to the most recent measurement of wavelengths of lines in laboratory spectra, the vast majority of Rowland's identifications are confirmed. A small proportion are recognized as misidentifications, some of them beyond doubt, many of them probable. These are noted, and where satisfactory evidence is available corrections are inserted. In addition to these alterations, there are many lines unidentified by Rowland, which can now, from the records accumulated since the publication of the Solar Tables in 1895–98, be with a high degree of probability assigned to their terrestrial equivalents. All the corrected and additional origins are tabulated, ready for final revision.

The probable identity of the lines constituting the well-known hydrocarbon band at λ 4314 with the equally well-known structure in the same region of the solar spectrum (Fraunhofer's *G*) has been under investigation at Cambridge in recent years. It has now been brought forward independently by Mr Baxandall. Although a comparison of Eder and Valenta's wave-lengths of the individual lines in the hydrocarbon spectrum between $\lambda\lambda$ 3900 and 4400 with Rowland's solar lines leaves little doubt as to the identity, photographs on a large scale of the hydrocarbon spectrum are desirable to confirm the identity and to exhibit

the convincing evidence. Laboratory work on the hydrocarbon spectrum mentioned in another part (Section D) of this report is being carried on in connection with this enquiry into the exact relationship of the hydrocarbon flutings to the solar spectrum and to stellar spectra of various types.

Some work has also been devoted to the discussion of the behaviour of the spectra of the many forms of carbon and carbon compounds as affecting typical celestial spectra. In the course of this enquiry, lines were found by Mr Baxandall in a published photograph of a certain carbon spectrum, which do not appear to have been recorded in any publication of carbon wavelengths. They afford suggestive evidence that these rare lines may explain some of the anomalies exhibited in the spectrum of Comet Wells (1882), the lines in which have never been satisfactorily accounted for. Experimental work to elucidate this matter further is necessary and will be undertaken when the opportunity presents itself.

Search has been specially made by Mr Baxandall with the object of elucidating the origin of conspicuous bright lines which appear in Moore and Sanford's published photographs of the spectra of η *Carinæ* and in Stebbins's photograph of the spectrum of *o Ceti*. No satisfactory evidence has been found for the appearance of the lines in any available records either of published wavelengths or of laboratory photographs.

B. *Solar Work.*

Spectroheliograph. Photographs of the sun's disc in $K_{2,3,2}$ light have been obtained on 112 days (previous year, 145), and photographs of the prominences at the limb on 93 days (previous year, 110). This work has been in the charge of Mr Butler, assisted by Mr Moss.

The plate holders have been adapted for smaller plates, and plates of the size 5 inches by 4 have been used since 1915 May 19.

On 19 April 1915 an unusually fine arched prominence appeared on the south-east limb of the sun. Mr Butler secured a good photographic record of it. A note relating to it was communicated to the Royal Astronomical Society in May and appears in the *Monthly Notices*, LXXV, 553. A remarkable feature of this arched prominence, which exhibited a maximum extension of nearly a quarter of a million miles from the sun's limb, was its short persistence; a photograph taken scarcely an hour later showed only the short basal portions of the earlier outburst.

The Director of the Kodaikánal Observatory has forwarded 322 spectroheliograms showing the solar disc in calcium ($K_{2,3,2}$) light for the year 1915 January 1—December 31 (previous year, 329). Of the 29 days missed in the Kodaikánal records there are Cambridge records for 15 days, so that solar records for calcium flocculi are available for 337 days in 1915.

In response to a request made last summer, Mr Royds has kindly taken 21 spectroheliograms at Kodaikánal at intervals of about an hour on three days 1916 January 3, 4 and 5. These excellent records are to serve for study of the duration of recognizable persistence of individual flocculi in unspotted regions of the sun's disc. Preliminary observations with a stereoscope show promise of results of value. The stereoscopic effect, which is barely detectable when the interval between the pictures is 1 hour, is very well marked when the interval is $2\frac{1}{2}$ hours.

Photoheliograms. Daily photographs taken with the Dallmeyer photoheliograph at Dehra Dûn have been received. The negatives are stored at the Science Museum, South Kensington. The positive prints have also been received from Dehra Dûn; but the work of mounting is in abeyance.

Study of Sun-spot Records. Mr Moss has continued his study of the areas and life-history of sun-spots from the Greenwich records 1881–1912. The tabulations of the areas are so far complete for spots and groups of durations 2, 3, 4, 5, 6, 7, 8, 9 days, that considerable progress has been made in the study of relation of area to duration, leading to analytical expressions,

which, though it is too early to speak with certainty, appear to point to a fairly complete similarity in the life-history of spots whatever their duration.

McClean Solar Instruments. Successful photographs of sun-spot lines in the spectral region between λ 5300 and λ 5500 have been obtained.

Mr J. B. Hubrecht's memoir on his investigations of the solar rotation from spectrographic observations made at Cambridge in 1911 has been printed and distributed as Part 1 of Volume III of the Annals of the Solar Physics Observatory.

The investigation exhibits novel features in method; and the results suggest that it is desirable to develope it or to find new alternatives in the mode of attack. In Mr Hubrecht's work the velocities in the line of sight are compared at points near the sun's limb differing in position by 90°, instead of being compared, as is usually done, at the ends of a diameter in different position angles. By this procedure, discrimination can be made between the rotational velocities at various latitudes in each solar hemisphere north and south of the equator, though determinate results are only obtained by assuming symmetry about the solar axis,—an assumption which is not only indicated by the observations but also more plausible than that generally adopted in the usual method. The definite results deduced emphasize the desirability of effectively making observations at the ends of parallel chords of the apparent sun's disc at various latitudes, a procedure whereby the determination of rotational velocities in either hemisphere would be made entirely independent of that in the other hemisphere, and the solution would be freed from indeterminateness. The equatorial velocity deduced from Mr Hubrecht's observations is abnormally low in comparison with the values obtained by other observers. He rightly refrains from laying stress on the absolute value deduced; for it is probable that this low value is due to some defect of symmetry in the optical conditions at Cambridge, though every effort was made to render them irreproachable, and no success has attended the effort made to detect want of symmetry. Apart from the low absolute values, the consistency of the results justifies the utilization of the material for study and discussion of the relative results, such as relate to the change of velocity with latitude, and the difference of behaviour of the northern and southern hemispheres. The research has led to two results, one expected, the other unexpected. The expected result shows that, at any rate at the epoch of the observations, there was a difference between the northern and southern hemispheres in regard to the distribution of velocity at different latitudes. The unexpected result discloses the fact that the velocity differences deduced from the different lines in the spectral region examined vary regularly from one end of the region to the other: and moreover, when once it had been recognized for the first time in this work, clear traces of a similar effect have been found in the work of other observers, who are in agreement as to the higher absolute value of the equatorial velocity. It is obviously a matter that calls for further investigation.

Reflecting prisms of special construction, made by Messrs Brashear of Allegheny, have been provisionally mounted on a bridgepiece in front of the slit of the large grating spectrograph, in order to afford comparative tests of two methods of observation for purposes of determining the solar rotation, one by simultaneous exposures for the two limbs, the other by successive exposures. Considerable modifications of the mounting of the prisms are needed before results of value can be obtained.

C. *Meteorological Physics.*

Investigations in Atmospheric Electricity. Mr C. T. R. Wilson has further developed and applied the method and apparatus mentioned in the last report. He has continued the study of lightning discharges and has obtained interesting results from a study of observations made in thunderstorms in the summer of 1915.

The sign and magnitude of the change produced in the earth's electrical field by the passage of a lightning discharge has been measured in about a hundred cases. In two

storms, those of August 12 and 15, 1915, it was found possible to get at the same time measurements of the distances of about 50 of these discharges by timing the arrival of the sound of the thunder. The changes of field resulting from the discharges and measured by the apparatus have varied between 15,000 volts per metre and 1 volt per metre. The change produced by a discharge at a distance of 10 kilometres generally exceeded 1000 volts per metre; on the assumption that the effect for greater distances falls off approximately according to the inverse cube law, it would appear that the apparatus can be used to measure the effects of discharges at distances even exceeding 100 kilometres.

In the case of a sufficiently distant discharge passing from the atmosphere to the earth it is possible to calculate from the data obtained the electric moment of the discharge, i.e. the product of the quantity of electricity discharged and the mean height from which it has been derived. The same method applies also to a vertical discharge passing between two points both in the atmosphere. The moment is proportional to the product of the change of field and the cube of the distance of the discharge producing it, if the latter is great enough compared with the height from which the discharge has come. The values of the moments obtained in this way have all been of the same order of magnitude; among these the larger values have been obtained for the greater distances and amount to about 10^{17} in electrostatic measure. Assuming that the vertical length of the discharge is between 1 and 10 kilometres, we find for the quantity of electricity passing in a single discharge something between 300 and 30 coulombs. But it is not necessary to make any assumption about the vertical length of the discharge; for the observations already obtained show that in certain storms there is sufficient similarity between the various discharges to make it possible, from the manner in which the magnitude of the effect depends on the distance of the discharge, to estimate both the quantity discharged and the height from which it has come; just as in the corresponding magnetic problem we might find both the length of a magnet and the strength of its pole by measuring the magnetic force due to it at different distances in its equatorial plane.

A paper describing the general methods employed in these investigations and the results obtained in relation to lightning discharges has been prepared for publication.

The additional apparatus required for automatic registration of the electrical effects has been constructed in the workshop. It is anticipated that the accuracy and extent of the observational material obtained will be thereby greatly increased.

D. *Work in the Laboratory.*

The continued detention at Odessa of the instruments taken to the Crimea has impeded progress. The temporary Littrow spectrograph which has been installed, consisting of two glass prisms of aperture 6 inches, refracting angle 45°, and a 6 inch photovisual objective of focal length 20 feet, disclosed faults in definition too great for the work undertaken. A troublesome examination showed the need for somewhat drastic diaphragming of certain parts of the beam. The changes thus necessitated have resulted in greatly improved definition, and work on the hydrocarbon spectrum is being continued in connection with the investigation referred to in Section A of this report. The envelope of green flame at the base of a Meker burner, which had been found to give the bands with remarkable brilliancy, susceptible of intensification by means of a special grid, is being used as one of the sources of light in the comparison. The work is being carried on by Mr Butler.

E. *Miscellaneous.*

A number of valuable publications have been received in the course of the year, and the Director desires to record his grateful acknowledgments to the donors. A list is appended.

Lectures were given in the October term, 1915, by Professor Newall on the Structure of the Sun and Thermodynamics. Mr G. W. Walker, F.R.S., who was appointed deputy, as

University Lecturer in Astrophysics, for Mr Stratton during the May term, gave a course of lectures on Terrestrial Magnetism.

As has been stated above, Volume III, Part I of the Annals of the Solar Physics Observatory has been distributed. To save trouble to librarians it should be stated that this is the only part of the Annals yet issued. According to the plan originally schemed—unfortunately liable to disabilities from the war and other causes—Volume I is intended to contain descriptions relating to historical matters and the present equipment of the Observatory, and miscellaneous matter; Volume II is to contain descriptions of stellar investigations, including work on Novæ; Volume III is to deal with solar work.

The Huggins Dome, the Reflector Dome and the outside of the Astrophysical Building were painted in September; and the inside walls of the Astrophysical Building were colour-washed.

H. F. NEWALL.

Solar Physics Observatory,
1916 *May* 20.

The Director gratefully acknowledges the receipt of the following works, which have been presented to the Library of the Solar Physics Observatory:

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Astrophysical Journal. Vol. XLI. 2—XLIII. 3. Chicago, 1915–16. 8vo.	Prof. Newall.
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Ottawa, Dominion Observatory. Publications. Vol. I. Nos. 13—16; Vol. II.; Vol. III. Nos. 1—5. Ottawa, 1914–16. 4to.	,,
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